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ABSTRACT

Helping students develop proficiency in the use of interpretive comprehension skills such as are required for reading mathematics and science materials becomes both a means for continuation of technological progress and a dimension of the kind of literacy needed for living and working successfully. The development of these skills must be sought in two major ways: as an integral part of the development process of reading throughout the elementary years, and as an objective of instruction in mathematics and science courses during the high school years. Several specific skills of interpretive comprehension should be the focus of instruction as students read mathematics and science materials: (1) prediction of outcomes, (2) drawing conclusions, (3) making generalizations, (4)perceiving relationships, (5) identifying implied sequences of events and ideas, (6) selecting implied cause-effect relationships, and (7) summarizing information. Among strategies for improving reading comprehension are questioning and the structured overview, which requires readers to focus on relationships between prior knowledge and current information and involves a diagram conveying major concepts in a unit of learning. (HOD)

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Developing Interpretive Comprehension Skills in Mathematics and Science

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Running Head: INTERPRETIVE COMPREHENSION

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DEVELOPING INTERPRETIVE COMPREHENSION SKILLS IN MATHEMATICS AND SCIENCE

While numerous influences affect students' abilities to read textual materials in content fields, none is more important than the kinds of instruction students receive during their years of schooling. For over half a century, both general and specific factors have been recognized as important in reading comprehension (Thorndike, 1917). In actual practice, however, there remains some uncertainty regarding where responsibility lies for the development of students' specific abilities for reading in the content field. On the one hand, classroom teachers and other special teachers of reading are expected to bear the onus for ascertaining that students learn to read and are prepared to use their reading ability for continued learning. On the other hand, teachers in content fields are held responsible for helping students develop the necessary abilities for reading textual materials unique in a specific field. The issue was recognized at least forty or more years ago (Artley, 1944).

A more moderate view is becoming increasingly popular. In this view, classroom teachers at the elementary school level, special teachers of reading, who may assist in the development of students' reading abilities at any level, and teachers in the content fields in high schools are,

together, faced with the challenge of helping students develop ability to read textual materials at an appropriate level of comprehension. As regards reading in mathematics and science fields, this challenge has become crucial as a result of current societal developments.

Highly industrialized nations are undergoing dramatic changes as a result of ever-expanding technologies. Instantaneous communication capabilities, rapid transportation, new sources of power, space explorations are but a few of the technological developments underscoring the urgency of education in mathematics and science. Modern societies need citizens who are well-informed, articulate and skilled in the scientific fields undergirding technological progress. Simultaneously, and of equal importance, is the need for citizens who can engage in problem-solving behavior, learn independently and make intelligent decisions about their economic, social and political welfare. Helping students develop proficiency in the use of interpretive comprehension skills such as are required for reading mathematics and science content becomes, at once, both a means for continuation of technological progress by societies and a dimension of the kind of literacy needed by many individuals for living and working successfully in the late twentieth century.

Development of interpretive comprehension skills in reading mathematics and science textual materials does not occur as a result of the application of a specified set of procedures at a given point in the education of students. Rather, development of these skills must be sought in two major ways. They must be included as an integral part of the developmental process of learning to read and reading throughout the elementary years. They must also become a consciously sought objective of instruction in specific courses in mathematics and science during the high school years. Teachers of reading and teachers of mathematics and science must work cooperatively in meeting this joint responsibility.

Teachers involved in helping students develop general and specific abilities in reading can best meet their joint responsibility by implementing their knowledge and competencies regarding three important facets of instruction. First, all teachers involved must be well-informed regarding the nature of interpretive comprehension skills and their relationship to other levels of comprehension. Secondly, they must understand the styles of writing characteristic of textual materials in mathematics and science. Finally, they must be able to use the kinds of instructional strategies that have been shown to be most

effective in improving students' use of higher comprehension skills.

The Nature of Interpretive Comprehension Skills

Classroom teachers and special teachers of reading, doubtlessly, are well-informed regarding the nature of comprehension and its achievement at increasingly higher levels. It must be recognized, however, that the results of reading instruction generally need improvement. There is wide recognition that students often have difficulty in mathematics and science because of poorly developed reading and thinking skills. At the same time, the numbers of students who drop out of schools or who graduate from high schools with minimal literacy skills are also deplorably high.

Teachers of mathematics or science, who have been known to protest being expected to teach aspects of reading, may be less-informed than are reading teachers regarding details related to an understanding of the nature of reading comprehension. Yet, if students are to use interpretive comprehension skills in reading content in the pertinent fields, teachers of mathematics and science must understand the nature of those skills. This understanding is basic to the provision of the kinds of experiences students need for development of their comprehension in reading content materials.

An understanding of the nature of comprehension includes recognition of the concept of "levels" of comprehension. Levels of comprehension are not indicative of different kinds or types of comprehension; nor are there distinct boundaries separating one level of comprehension from another level. The higher levels of comprehension are inclusive of the lower levels and the effect is cumulative rather than differential. It has been pointed out that the first level of comprehension is not lost in the second or any subsequent level. Each level simply goes further into the acquisition of meaning than the preceding level (Adler, 1972). Development of interpretive comprehension skills is based on the assumption that the reader already comprehends the material at the literal level. Development of interpretive comprehension skills also facilitates subsequent development of ability to use critical comprehension skills.

Although there are some minor differences in terminology, the categorizations of cognitive skills as portrayed in some widely known taxonomies are helpful in clarifying the concept of levels of reading comprehension. The close correlation between levels of cognition and levels of reading comprehension is not accidental. A classic definition even holds reading and thinking to be synonymous (Thorndike, 1917). Thus, it is reasonable that in each of

three taxonomies for cognitive learning (Bloom, 1956, Sanders, 1966, Barrett, 1968), the levels of cognition compare with the literal, interpretive and critical levels of reading comprehension.

Simply stated, reading comprehension at the literal level requires the reader to recognize or recall ideas, information or relationships that are explicitly stated in the text. Reading comprehension at the interpretive level requires the reader not only to recognize or recall but, also, to make relationships between that which is explicitly stated and that which may be implied. In order to make the essential relationships, the reader often must call upon internalized ideas which have previously resulted from personal experiences, either real or vicarious. Attainment of the critical level of comprehension requires the reader to use the knowledge and understandings gained at both the literal and interpretive levels and apply evaluative criteria to determine the worth or value of ideas encountered in the text.

Ability to use interpretive comprehension skills prepares the reader to attain critical reading comprehension ability. Critical comprehension ability is important in both mathematics and science and representative of the ultimate goal of effective reading. Helping students develop interpretive comprehension skills is not an end

within itself but an important means to achievement of a still higher level of reading comprehension.

There are several specific skills of interpretive comprehension that should be the focus of instruction as students are helped to read materials of a general nature and those specifically applicable to mathematics and science. Among these skills are: (1) prediction of outcomes, (2) drawing of conclusions, (3) making generalizations, (4) perceiving relationships, (5) identifying implied sequences of events and ideas, (6) selecting implied cause-effect relationships and (7) summarizing information. These skills are highly interrelated. Ability to use any one of the skills generally implies ability and need to use many of the others simultaneously. All of the skills require the reader to arrive at meaning as a result of the combination of ideas encountered in reading and those derived from former or concurrent experience.

Classroom teachers are in a unique position for helping students develop ability to use interpretive comprehension abilities both in general reading and in mathematics and science classes at elementary levels. Often the classroom teacher not only teaches reading but also teaches elementary mathematics and science. Textual materials in mathematics and science are usually used from the first grade throughout

the elementary curriculum. While it cannot be assumed that transfer of skills learned in general reading in the elementary curriculum will ensue, automatically, when students are required to read mathematics and textual materials in high schools, provisions can be made for immediate transfer of skills from one class to another in elementary classrooms.

Special teachers of reading can provide supplementary experiences in utilization of interpretive comprehension skills by students who fail to develop proficiency in regular elementary or secondary classrooms. Furthermore, special teachers of reading can serve as valuable resources to provide assistance to classroom teachers and teachers of mathematics and science. This assistance can range from recommending essential materials of instruction to the provision of staff development activities on individual or group bases.

Teachers of mathematics and science classes at high school level are responsible for the continued development of students' capabilities to read their immediate textual materials effectively. Instruction related to how materials should be read is an integral part of the subject matter of content fields. If a developmental approach to the use of interpretive comprehension skills has occurred during the elementary school years, the task will be easier. Students

should be helped to make relationships between what they have previously learned both in techniques of reading and in content, and what they are currently being taught.

Writing Styles of Textual Materials in Mathematics and Science

Effective reading in mathematics and science content is facilitated when the reader knows what to expect in the organization and presentation of materials. Likewise, when the reader expects the language used in the materials to follow certain patterns, there can be a positive effect on the reader's readiness for reading. All teachers involved in helping students develop ability to read mathematics and science textual materials should be aware of the writing styles typically characterizing the materials. They should make students aware of these writing conventions and their effect on reading comprehension.

Because of the close relationship between mathematics and many of the sciences, readers are required to use many of the same types of skills in comprehension of the content in each field. Writing styles used in the respective fields tend to reflect a high degree of similarity, compactly conveying many different concepts in relatively brief passages. Typically, a reading selection may include a mixture of words, mathematical symbols, abbreviations, graphic materials and the like. Readers are required to

make many relationships, reflect, reason and infer on the basis of many ideas not explicitly stated in the texts.

Vocabulary and its usage in mathematics and science materials present a challenge for many students. Technical and specialized vocabularies often cause difficulty. Having a generalized understanding of the meanings of these types of vocabularies and their functions can be a useful initial step toward effective comprehension. Classroom teachers and special teachers of reading can begin early to help students understand the significant role played by vocabulary in reading comprehension. Teachers in mathematics and science can make specialized and technical vocabularies an integral part of the content to be mastered in each subject area.

In mathematics, complex ideas generally are presented through use of the passive voice. Symbols are used proliferately and may be direct or indirect substitutions for words or for implying meanings in the absence of words. For example, the use of brackets, parentheses, or plus (+) or minus (-) signs may communicate meaning without reference to a particular word. The usual left-to-right direction of reading is often impossible because many of the conventions for interpreting symbols in mathematics depend on spatial organization of the symbols. Frequently, understanding of the content requires interpretation of accompanying geometric diagrams or graphs.

In science, some of the special writing patterns are classification, explanation of technical processes, instructions for performing an experiment, interpretation of cause-effect patterns, and problem-solving situations.

Effective development of interpretive comprehension skills in mathematics and science is facilitated for students when they are helped to recognize writing styles characteristically used in these fields. Throughout all levels of schooling, effective reading instruction should help students develop general meanings for dealing with vocabulary, symbolic representations, abbreviations, graphic clues and the like. Faced, eventually, with reading in mathematics and science, students will have some prior knowledge and understanding of these devices and will be more able to recognize relationships required for comprehension of the material at the interpretive level.

Strategies for Encouraging Use of Interpretive Comprehension Skills in Mathematics and Science

Knowledge of the nature of interpretive comprehension skills and of the writing styles of mathematics and science textual materials are not, alone, sufficient for making sure that students will read the necessary materials at an appropriate level of comprehension. It is also essential for teachers to use a variety of instructional strategies for bringing students and materials together in productive

ways. Students need to visualize clear purposes for their reading and to accept these purposes as important to their concerns. Students need to be interested in what they are required to read and motivated to seek the fullest possible meanings. Students need to build bridges between their past experiences and new experiences. Several strategies of instruction are available to teachers for facilitating recognition of all of these principles in the development of students' comprehension abilities.

For over 2000 years since Socrates used questioning effectively to arrive at the truth, questions have been a part of teaching. Among strategies for improving reading comprehension, questions are, perhaps, the oldest and most widespread. Used judiciously and perceptively, questions can be an effective means whereby students are led to interpret the meanings of what they read. Available evidence, however, suggests that considerable improvement is needed in teachers' use of questions as a strategy for improving reading comprehension.

Austin and Morrison (1964) reported that teachers appeared to equate reading-thinking skills with the most narrow, literal comprehension skills. Guszak (1967) found that the most frequent kind of comprehension questions asked by teachers in his study were at the literal level, especially in the primary grades. Gall (1970) reported that

in half a century there had been no essential change in the types of questions teachers emphasized in the classroom. Only twenty percent of teachers' questions required students to think. The rest only required them to recall facts or procedures. Durkin (1978) reported from her classroom observations of content teaching that more attention was focused on covering content and mastering facts than on the improvement of comprehension.

Yet the value of questioning as an effective strategy for helping students develop ability to use interpretive comprehension skills must not be overlooked. Farrar (1984) noted the pervasive influence of questioning as a means for stimulating thought. Durkin (1981) observed that questions can be a means for understanding information processing and a means for augmenting what is read. Hunkins (1972) declared that effective materials and stimulating situations will be of no value if teachers lack skill in formulating questions and in using various questioning strategies.

Evidence shows that teachers need to improve their questioning strategies. Evidence also indicates that using strategies of questioning can result in helping students comprehend materials at increasingly higher levels of thinking. In mathematics and science, teachers must design and ask questions at the interpretive level of comprehension, if students are expected to comprehend at

that level. Unquestionably, the quality of teacher's questions are strong determinants of the manner in which students read.

As useful as questions might be when they are well-planned and asked in such a way that they require use of higher thinking abilities in responses, other strategies should be implemented by teachers of reading, mathematics and science. At times, use of other strategies can serve to make questions more useful in stimulating thought. Furthermore, teachers need to use a variety of strategies in order to accommodate the variety of individual differences reflected in learning styles, abilities, interests and motivation among students in a classroom. Often, this can be done through use of novel and stimulating strategies that require students to utilize comprehension skills in active rather than passive ways. One such strategy is the "structured overview." The structured overview requires readers to focus on relationships between the knowledge they have acquired previously and the concepts and ideas they are currently encountering in reading materials. Known by various other names, including "advance organizer" or "graphic organizer," a structured overview can be developed by teachers or students and by teachers and students, cooperatively.

A structured overview is a diagram that graphically conveys major concepts and other concerns in a unit of learning. Important terms of vocabulary and concepts can be presented in a form that suggests their relationships. Useful in any content field, the structured overview is easily adapted for use in studying mathematics and science materials. Barron's (1972) research on the usefulness of the structured overview preceded many variations now described in leading texts on methods of teaching reading in content fields (Cheek and Cheek, 1983; Zintz, 1984).

Classroom teachers should introduce students to the construction and use of structured overviews during the elementary years. At more advanced levels, students will be able to use the strategy independently and according to their own needs and inclinations.

Steps in constructing a structured overview involve: (1) a recognition of important concepts to be studied in order to understand the given content, (2) a list of essential vocabulary terms arranged to show the relationships among the concepts being studied and (3) a graphical arrangement of the vocabulary and concepts emphasizing relationships among the concepts under study. Guiding questions and other introductory activities should be used to help students understand the strategy and to help them contribute other ideas in its development.

Students throughout the elementary grades and during high school should also be taught organized study strategies for use as appropriate in reading mathematics and science content. Teachers must understand use of these strategies and make sure that students understand them, thoroughly, or students will not attempt to use them as they read. Teachers should understand that they are not dealing with extraneous concerns when they take the time to teach organized study strategies and their use in reading content materials. Study strategies should be considered integral in the teaching of reading in elementary schools and in the teaching of subject content. Francis Robinson's (1961) original study strategy "SQ3R" should be taught as a general approach to studying the content of any subject field including those of mathematics and science. Briefly, SQ3R directs the reader to: (1) survey, (2) question, (3) read, (4) recite and (5) review the reading material. For specific use in helping students read mathematics word problems is the study strategy SQRQCQ, developed by Leo Fay (1966). The six steps in SQRQCQ direct the reader to: (1) survey the word problem for general information, (2) question to determine exactly what is being asked, (3) re-read the problem for details and to note relationships, (4) question to determine essential processes, (5) compute, based on the result of step 4, and (6) question the answer

to see if it is logical in terms of what was called for in the problem. For special application to reading science content, George Spache's and Paul Berg's (1966) PQRST is highly recommended. The steps of PQRST direct the reader to preview, question, read, state the information and test themselves on what they have read. Although deceptively simply stated, these study strategies require careful attention and repeated efforts in order to become useful tools for use in reading mathematics and science. The potential of these strategies for encouraging students to read and understand what they have read at the level of interpretation justifies the time and effort required for their development.

Strategies described here and many others can be used to improve students' use of interpretive comprehension skills in mathematics and science. These should be used in the instructional approaches of teachers of reading and of teachers of mathematics and science. In many cases, the strategies needed for facilitating understanding of the content must be stressed during instruction to a degree equal to that placed upon the content students are expected to learn.

A Final Statement

There are several indications that the task of helping students develop interpretive comprehension abilities for

reading mathematics and science textual materials is being viewed, increasingly, as one that must be shared by several members of the team of educators by whom a student is taught throughout all levels of schooling. Inclusion of courses in methods and procedures for teaching reading through content can be seen in many programs of teacher education at undergraduate and graduate levels. Many recent textbooks focused on teaching reading through content are now available for use by prospective teachers and teachers in service. There is a growing variety of supplementary materials for use by students in mathematics and science classes in the schools.

While education in mathematics and science is more important, from national and individual perspectives, perhaps than at any previous time in history, there is also recognition that progress in these fields depends on individuals' abilities to read and think at higher levels of comprehension. The challenge for all teachers, involved, is of such nature that they must understand the nature of the comprehension abilities they are attempting to help students develop, the nature of the writing styles to which comprehension applies, and the wide variety of teaching strategies that can be used for its development.

References

Adler, Mortimer J. and Charles Van Doren (1972). How to read a book (revised) New York: Simon and Schuster.

Artley, A. Sterl (1944). A study of certain relationships existing between general reading comprehension and reading comprehension in a specific subject matter area. Journal of Educational Research. 37, 464-473.

Austin, Mary C. and C. Morrison (1964). The first r: The Harvard report on reading in elementary schools. New York. Macmillan.

Barrett, Thomas C. (1968). Taxonomy of cognitive and affective dimensions of reading comprehension. In Theodore Clymer (Ed.). Innovation and change in reading instruction: Sixty-seventh yearbook, national society for the study of education: Part 2. Chicago: University of Chicago Press.

Barron, Richard F. (1972). The effects of advanced organization and grade level upon the reception learning and retention of general science content. In Frank P. Green (Ed.). Twenty-first yearbook of the national reading conference, Milwaukee, WI: National reading conference. (pp. 8-15).

Bloom, Benjamin S. et. al. (Eds.). (1956) Taxonomy of educational objectives handbook I - cognitive domain. New York: David McKay

Bermuth, John (April, 1968). The Cloze readability procedure. Elementary English. 45. 429-436.

Cheek, Earl H., Jr. and Martha Collins Cheek (1983). Reading Instruction through Content Teaching. Columbus, Ohio: Charles E. Merrill Publishing Co.

Durkin, Dolores (1978-79). What classroom observations reveal about reading comprehension instruction. Reading Research Quarterly XIV. 4. 481-533.

Durkin, Dolores (January, 1981). What is the value of the new interest in reading comprehension? Language Arts. 58. 23-43.

Farrar, Mary Thomas (February, 1984). Why do we ask comprehension questions? A new conception of comprehension instruction. Reading Teacher. 37. 6. 452-456.

Fay, Leo (1966). Reading study skills: Math and science. In J. Allen Figurel (Ed.). Reading and inquiry. Newark, DE: International Reading Association. 93-94.

Gall, M. D. (1970). The use of questions in teaching. Review of educational research. 40, 707-720.

Guszak, Frank J. (December, 1967). Teacher questioning and reading. Reading Teacher. 21, 3, 227-234.

Holmes, Betty C. (November, 1983). A confirmation strategy for improving poor readers' ability to answer inferential questions. Reading Teacher. 37, 2. 144-148.

Hunkins, Francis P. (1972). Questioning strategies and techniques. Boston, MA: Allyn and Bacon.

Kane, Robert D., Mary Ann Byrne and Mary Ann Hater (1974). Helping children read mathematics. New York: American Book Co.

Robinson, Francis P. (1961). Effective study (rev. ed.). New York: Harper and Row.

Sanders, Norris M. (1966). Classroom questions: What kinds? New York: Harper and Row.

Spache, George D. and Paul C. Berg (1966). The art of efficient reading. New York: Macmillan.

Thorndike, Edward L. (1917). Reading as reasoning: A study of mistakes in paragraph reading. The Journal of Educational Psychology. 4, No. 6, 323-332.

Zintz, Miles V. and Zelda R. Maggart (1984). The reading process: the teacher and the learner. Dubuque, IA: William C. Brown Publishers.